AIUB-RL02 monthly gravity fields from GRACE data

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1. GRACE monthly gravity fields from AIUB

The Astronomical Institute of the University of Bern (AIUB) computes monthly gravity fields from GRACE GPS and K-Band range-rate observations with the Celestial Mechanics Approach (Beutler et al, 2010) incorporating:

- a dynamic method based on numerical integration of the satellites' equations of motion,
- the use of kinematic orbits (and covariance information) as pseudo-observations,
- the estimation of constant and constrained pseudo-stochastic accelerations every 15 min in three directions (radial, along-track, cross-track) to compensate model deficiencies,
- no further empirical K-Band parameters.

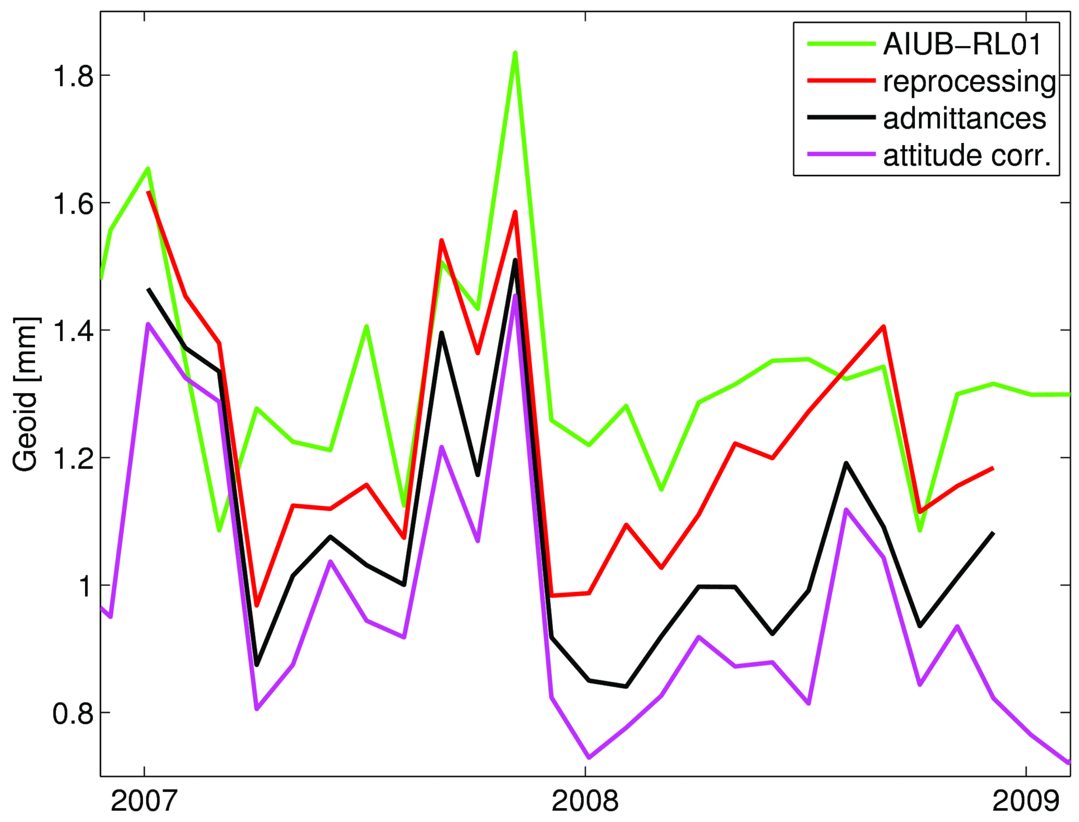

Fig: 1: Noise (weighted RMS over the oceans) reduction by model improvements in 24 monthly solutions.

2. From AIUB-RL01 to AIUB-RL02

A first series of monthly fields (AIUB-RL01) based on GRACE L1B-RL01 data was released in 2011 (Meyer et al, 2012). Its successor AIUB-RL02 will be made available by the end of 2013 at ICGEM.

New features are (Fig. 1):

- based on reprocessed GRACE L1B-RL02 data and AOD1B-RL05 de-aliasing products,
- updated background models: AIUB-GRACE03S to l_{max}=160 including time-variations to l_{max}=30, ocean tide model EOT11A to l_{max}=100 including admittances,
- reprocessed kinematic orbits based on ITRF 2008,
- IERS 2010 conventions (RL01 was based on IERS 2003),
- inclusion of observed cross-track accelerations (omitted in RL01),
- K-Band attitude correction applied (omitted in RL01 due to noisiness),
- ocean pole tides modeled.

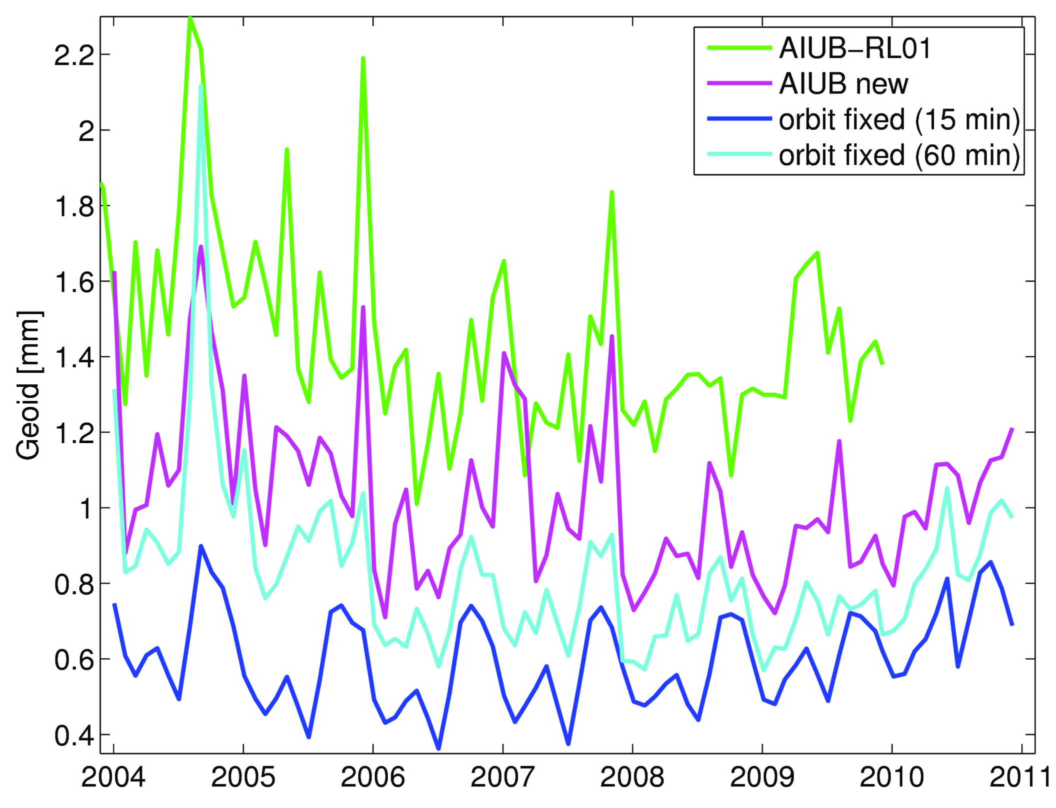

Fig: 2: Noise reduction by model improvements (purple) and the possible further improvement by fixing the orbits (with 15, or 60 min stoch. acc.).

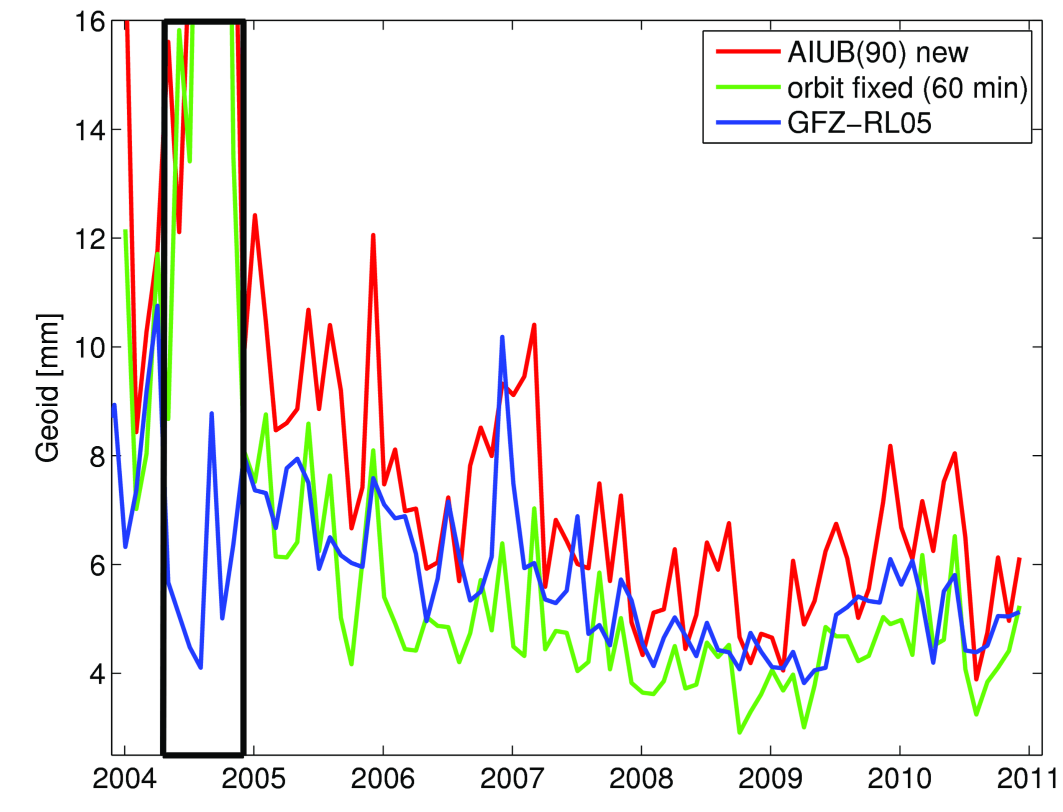

Fig: 6: Noise of monthly solutions complete to degree and order 90, for comparison GFZ-RL05 (blue). Repeat period in fall 2004 was Kaula-regularized in GFZ solutions.

3. Fixing the orbit

Experiments were made to separate the estimation of arc specific (orbit-) and gravity field parameters. The suppression of correlations between these two parameter types considerably reduces the noisiness of the monthly gravity models (Figs. 2 and 4a+b). This can be explained by a regularization of the gravity field coefficients. Unconstrained accelerations every 60 min were found to be a good compromise between noise suppression and signal conservation. More frequent stochastic parameters begin to dampen the time variable signal visibly (Fig. 3).

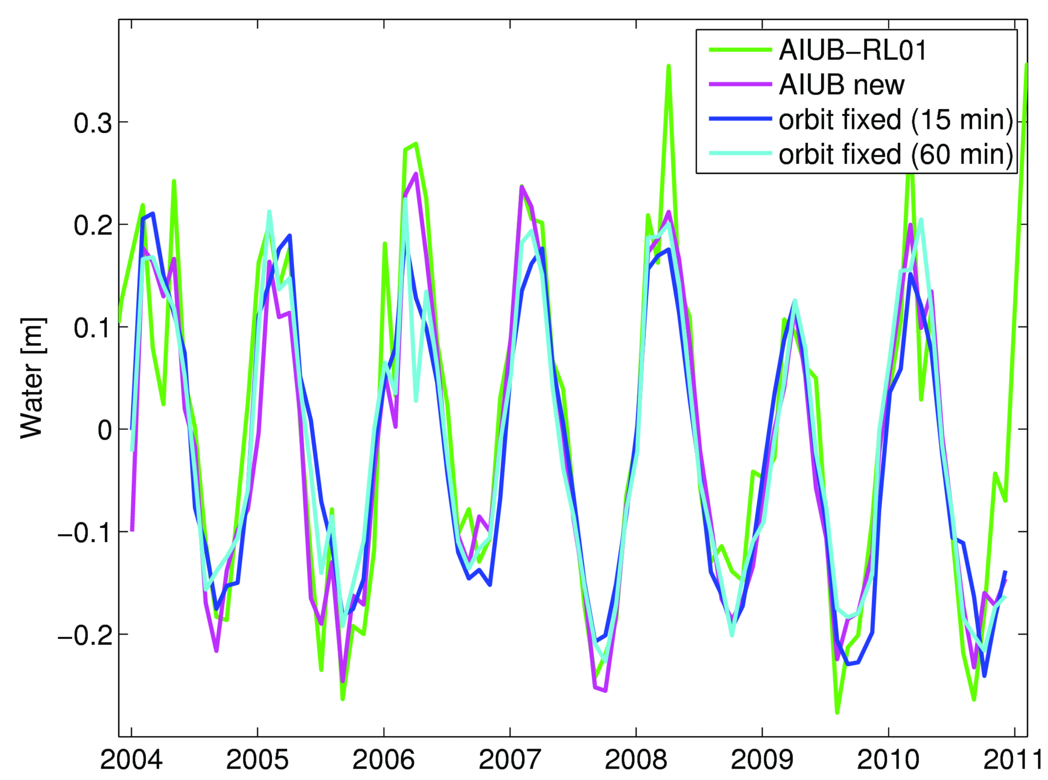

Fig: 3: Time variable gravity signal in Amazon. For fixed orbit solutions a slight damping becomes visible.

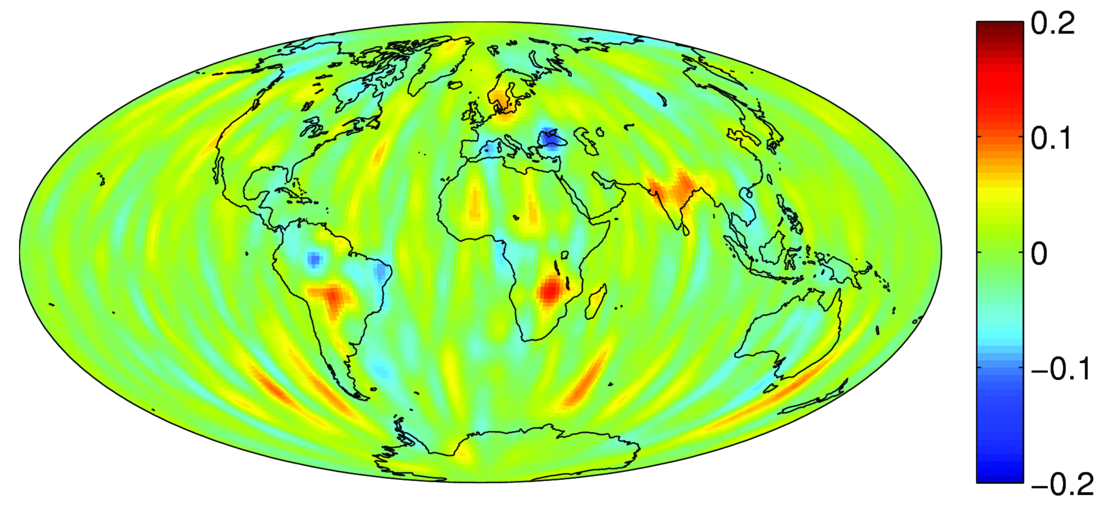

Fig: 4a: Differences between monthly model 2008/03 (reprocessed solution to l_{max}=60) and time variable a priori AIUB-GRACE03S, evaluated at 2008/03/15 (in equivalent water heights [m]).

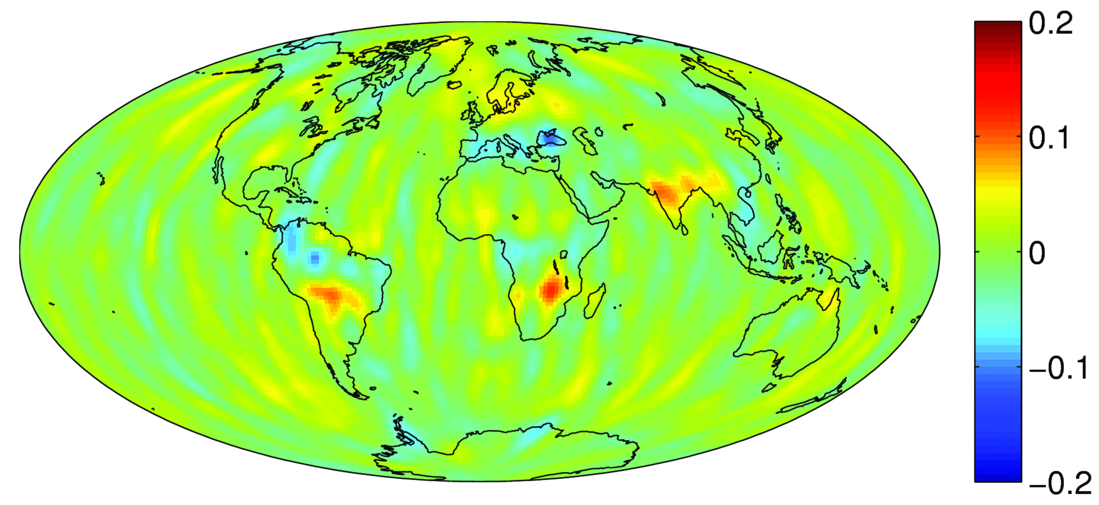

Fig: 4b: Like 4a, but orbits fixed (60 min stoch. acc.)

4. Sensitivity to time variations

A six parameter model (bias, trend, annual and semi-annual periodic variations) was fitted to each of the gravity field coefficients and the estimated parameters were statistically tested for their significance. For low orders a max. degree of 60 was found not to be sufficient to capture all observable variations (Fig. 5, left column), while a max. degree of 90 seems to be to high and adds unnecessary noise to the unfiltered solutions (Fig. 6). In Fig. 5 (right column) the regularization effect becomes visible for all coefficients with time variable a priori values (up to degree and order 30).

5. C_{20} replaced by SLR analysis

The value of C_{20} in the a priori model AIUB-GRACE03S is known to be of poor quality. It was therefore decided to replace it by a SLR-derived model (Sosnica et al, 2013). Figure 6 strikingly illustrates the regularization effect of fixing the orbits. The a priori values are almost perfectly reproduced, irrespective of how wrong they are.

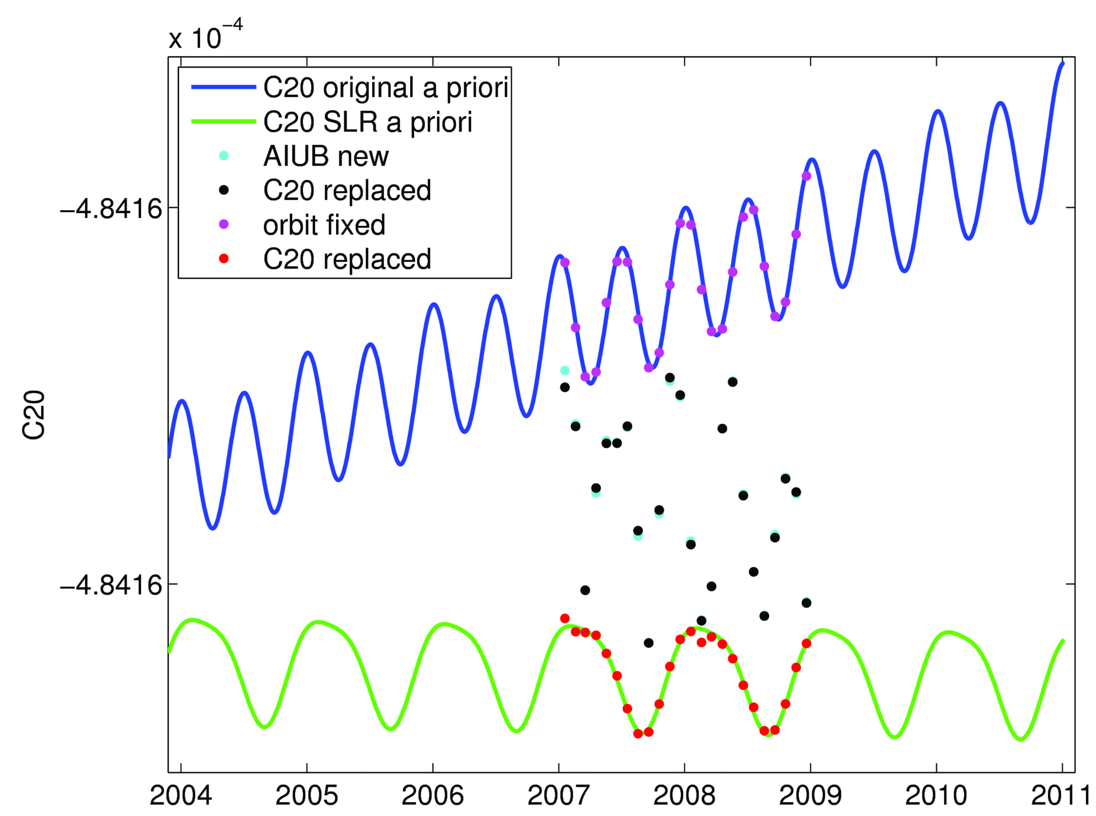

Fig: 6: A priori values of C_{20} (original (blue) and SLR (green)) and estimated monthly coef. (red/purple with fixed orbit (60 min)).

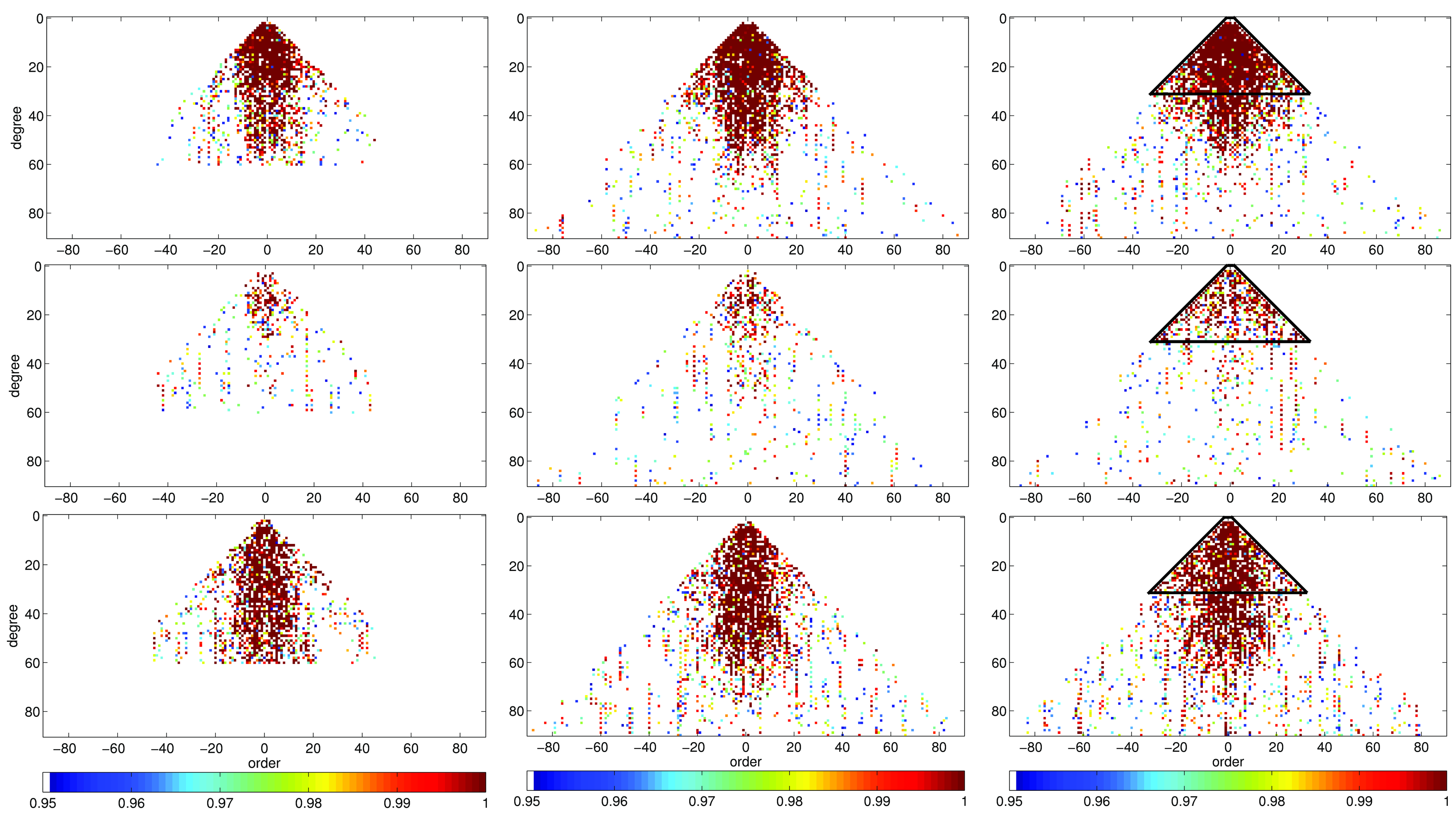

Fig: 5: Significance of estimated time variations (top row: annual, middle row: semi-annual, bottom: trend) per gravity field coefficient (left part of triangle: S-, right part: C-coef.). Left column: AIUB-RL01, middle column: reprocessed, right column: orbit fixed (60 min).

6. Summary

AIUB-RL02 will comprise the improvements listed in Sect. 2. The max. degree will be chosen between 60 and 90. GRACE data will be combined with SLR data to amend the estimation of C_{20}. We refrain from fixing the orbits to avoid signal loss (while the noise can be dealt with in a post processing step).

7. References

Beutler G, Jäggi A, Mervart L, Meyer U (2010) The celestial mechanics approach: theoretical foundatiions. JGeod 84:661-681

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Sosnica K, Jäggi A, Thaller D., Dach R, Beutler G (2013) Contribution of Starlette, Stella, and AJISAI to the SLR-derived global reference frame, JGeod, in preparation

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